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Prospects for the Use of Carboxytherapy in Comprehensive Care for Problematic Skin

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Abstract

This article presents a comprehensive analysis of the prospects for applying non-injection carboxytherapy within integrated care programs for problematic skin, taking into account contemporary demands for efficacy, safety, and physiological compatibility of interventions. The study is grounded in an interdisciplinary framework combining clinical dermatology, cosmetology, skin physiology, and evidence-based medicine. Special attention is paid to secondary analysis of scientific literature describing the effects of transdermal and topical CO_2 application on vascular, pigmentary, and structural skin parameters in patients with acne, post-acne, striae, hyperpigmentation, and early cellulite. Both visual-instrumental and clinical outcomes are examined—including skin hydration, elasticity, microcirculation, lymphatic drainage, and patient satisfaction. Findings indicate that noninvasive CO_2 modalities—such as gel formulations, masks, and device-assisted transdermal delivery—produce significant clinical improvements, particularly in the periorbital area and regions with compromised turgor, while maintaining a high safety profile and requiring no recovery time. A comparative review with alternative approaches (PRP, fractional CO_2 laser, IPL) highlights the superior tolerability and multifunctional benefits of noninvasive carboxytherapy, especially for patients with sensitive or thin skin. Limitations of the current evidence base are also identified: variability in treatment protocols, short observation periods, and the lack of standardized efficacy scales. The necessity for methodological standardization and an increase in randomized controlled trials is substantiated. This article

will be of value to specialists in aesthetic medicine, clinical dermatologists, skin physiology researchers, and developers of personalized, multitargeted skincare regimens.

Keywords: non-injection carboxytherapy, problematic skin, transdermal delivery, CO_2 gels, periorbital area, striae, hyperpigmentation, microcirculation, physiological skincare, aesthetic dermatology.

Introduction

Contemporary cosmetology—both within countries boasting established dermatological care systems and in private aesthetic medicine settings across the post-Soviet region—is undergoing a significant shift driven by a reappraisal of the balance between efficacy and invasiveness of treatments. Increasing prevalence of skin sensitivity, heightened susceptibility to inflammatory reactions, and chronic dermatoses across all age groups have prompted a move toward physiologically gentle techniques. In this context, interest is growing in non-injection carboxytherapy: a modality relying on localized application of carbon dioxide to enhance microcirculation, tissue oxygenation, and regenerative processes without compromising skin integrity.

Particular attention in both research and practice has focused on transdermal CO_2 therapies—gel applications, masks, and device-based methods—that facilitate gas exchange with the skin via pressure gradients and physicochemical reactions at the epidermal surface. Clinical interest in these approaches is exemplified by multi-stage care protocols for acne, post-acne sequelae, and chronic skin hypoxia. Because they avoid breaching the skin barrier, non-injection carboxytherapy becomes the method of choice when invasive procedures are contraindicated or impractical.

These techniques establish a distinct skincare paradigm aimed at stimulating the skin's innate physiological mechanisms without needles—an imperative given today's rigorous demands for safety, patient compliance, and minimized recovery time. Unlike injectable carboxytherapy—traditionally employed for contouring local fat deposits or treating periorbital wrinkles—non-injection carboxytherapy is positioned as a versatile maintenance tool suitable for routine use.

The aim of this study is to analyze the physiological effects, clinical outcomes, and applications of non-injection carboxytherapy in the management of problematic and sensitive skin; to substantiate its efficacy within comprehensive dermocosmetic restoration protocols; and to identify directions for future research in non-invasive CO_2–based methodologies.

Materials and Methods

The methodological framework of this study is situated at the crossroads of clinical dermatology, aesthetic medicine, and physiological cosmetology, reflecting the interdisciplinary nature of analyzing non-injection carboxytherapy's efficacy in correcting aesthetic skin imperfections. The principal analytical tool is a qualitative content analysis of both scientific and applied literature addressing the mechanisms of transdermal CO_2 action, its effects on skin condition, and its incorporation into non-invasive skincare regimens.

Our review draws on sources encompassing clinical overviews and applied studies of skin hydration, elasticity, vascular and pigmentary disorders, textural changes, and cellulite. Particular emphasis is placed on the work of Kołodziejczak [1], which reports changes in hydration and viscoelasticity of the lower-eyelid skin following CO_2 monotherapy and combined CO_2–acid treatments, and on Kołodziejczak and Rotsztejn [2], who demonstrate carboxytherapy's impact on the vascular and pigmentary components of periorbital dark circles. We also consider systematic reviews by Martignago et al. [3], Kroumpouzos [4], and Zelenkova [5], which synthesize clinical outcomes of CO_2 application for striae, cellulite, and age-related skin changes.

Separate attention is given to Bagherani's reviews [6, 10], which establish the therapeutic relevance of CO_2 interventions across various dermatological conditions, and to Peixoto [7], who examines carboxytherapy's role in acne-scar management. The publications by Qoreishi [8] and Kumar [9] are analyzed for their insights into positioning CO_2 modalities within emerging non-invasive and minimally invasive skin-rejuvenation strategies, with a focus on the interface between aesthetic correction and dermatological care.

Thus, our methodological strategy relies on a comparative analysis of theoretical models, clinical data, visual-instrumental metrics, and safety parameters used to evaluate carboxytherapy's effectiveness. This integrative approach has revealed a solid rationale for viewing non-injection CO_2 treatments as an independent modality for managing vascular,

pigmentary, and structural skin disturbances.

Results

Analysis of current data on non-injection carboxytherapy reveals consistent physiological and visually measurable skin improvements in response to superficial carbon dioxide exposure. Use of gel masks, transdermal applications, and device-assisted CO_2 delivery triggers a cascade of reactions affecting the microcirculation, superficial capillaries, and epidermal structures without breaching skin integrity.

One of the most reproducible findings, reported by Kołodziejczak [1], is increased hydration and elasticity in the periorbital region. Both patient-reported outcomes and high-elasticity measurements confirm this effect. In the study by A. Kołodziejczak and H. Rotsztejn [2], combined gel formulations containing CO_2 and acidic components significantly reduced under-eye dark circles, correlating with regression of vascular and pigmentary factors. In both protocols, gas diffusion through the stratum corneum—rather than needle penetration—mediated the change.

According to the review by Zelenkova [5], transdermal CO_2 therapies produce capillary dilation, improved local tissue nutrition, and increased dermal density, effects that are most pronounced with repeated treatment courses. Ultrasound and dermatoscopic imaging confirm these structural shifts. Kroumpouzos [4] similarly highlights enhanced tissue respiration and stimulated lymphatic drainage, especially in chronically hypoxic skin zones. Bagherani's overview [6] further synthesizes the dermatophysiological mechanisms and clinical manifestations of these non-invasive CO_2 interventions.

All examined studies report durable positive outcomes: increased turgor, more even skin tone, reduced puffiness, and normalized capillary blood flow. Assessment methods include corneometry, dermatoscopy, visual analog scales (VAS), and expert photographic analysis. These findings substantiate CO_2's effectiveness within a physiologically compatible framework and minimal risk of adverse reactions. A detailed comparative summary of application methods, treatment zones, characteristic effects, and their verification techniques is provided in Table 1.

Table 1 – Observed Physiological Skin Responses to Non-Invasive Carboxytherapy (Compiled by the author based on sources: [1], [4], [5])

Application Method	Observed Effect	Clinical Area	Assessment Modality
Gel-based CO_2 mask	Improved hydration and skin elasticity	Periorbital region	Corneometry, viscoelasticity meter
CO_2 with acid peel mask	Reduction in pigment and vascular dark circles	Infraorbital zone	VAS, colorimetric imaging
Topical CO_2 gel	Enhanced microcirculation and skin density	Cheeks, thighs	Ultrasound imaging, dermatoscopy
Transdermal device delivery	Stimulation of tissue oxygenation and lymphatic flow	Hypoxic dermal areas	Clinical observation, skin thermometry
CO_2-enriched gel protocols	General dermal revitalization and tone unification	Face, neck	Expert panel, visual scoring

The data presented in Table 1 confirm that transdermal CO_2 application can induce targeted, predictable changes in skin physiology comparable in direction to those achieved by invasive techniques, while offering a markedly higher safety and tolerability profile.

An examination of current evidence on non-injection carboxytherapy highlights consistent physiological and visually measurable improvements in skin parameters following superficial CO_2 application. Gel masks, transdermal patches, and devices delivering controlled CO_2 stimulate a cascade of responses—enhancing microcirculation, dilating superficial capillaries, and reinforcing epidermal structures—without compromising skin integrity.

Martignago [3]'s systematic review documents significant improvements in areas with pronounced lipodystrophy—particularly the thighs, buttocks, and abdomen—after regular use of CO_2-enriched masks. Patients experienced a reduction in subcutaneous unevenness and an improvement in skin texture, corroborated by both clinical assessments and standardized visual scales.

Zelenkova [5] demonstrates that transdermal CO_2 therapy serves as an effective physiological treatment for chronically hypoxic or microvascular-impaired skin, especially in age-related and stress-associated dermatology. Protocols targeting the cheeks, chin, and neck yielded durable gains in capillary blood flow and restoration of the epidermal barrier.

Bagherani [6] synthesizes data showing that non-invasive CO_2 can be adapted across diverse dermatological applications—from soothing sensitive skin to enhancing recovery following aggressive procedures—underscoring its versatility within comprehensive aesthetic rehabilitation programs.

The periorbital area—particularly prone to adverse reactions from invasive treatments—also responds well to non-injection CO_2. Kołodziejczak [1], in collaboration with Rotsztejn [2], reports that CO_2 masks and topical applications reduce dark circles, puffiness, and hyperpigmentation by locally enhancing microcirculation and lymphatic drainage. This effect is especially valuable in patients with thin, inflammation-prone skin.

Kroumpouzos [4] emphasizes the method's clinical importance for hypersensitive skin, where other interventions may provoke flare-ups or exceed the patient's tolerance threshold. In such cases, CO_2 formulations function both to beautify and to reinforce the skin's barrier.

The collective data allow us to identify representative clinical indications, target areas, and expected outcomes, as summarized in Table 2.

Table 2 – Target Indications for Non-Invasive CO_2-Based Therapies in Aesthetic Dermatology (Compiled by the author based on sources: [1], [3], [5], [6])

Indication	Skin Area	Preferred Formulation or Technique	Clinical Outcome Reported
Striae distensae	Abdomen, thighs, hips	O_2 gel mask	Improved skin texture and elasticity
Cellulite	Buttocks, posterior thighs	Topical CO_2 + massage	Reduced dimpling, smoother skin surface
Infraorbital hyperpigmentation	Periorbital zone	CO_2 mask with acids	Brightening, reduced puffiness and darkness
Age-related dullness	Cheeks, jawline, neck	Topical CO_2 formulations	Enhanced vascular tone, skin revitalization

Sensitive skin management	Face, especially reactive areas	Mild CO_2 creams/masks	Restored barrier function, reduced sensitivity
Multitarget skin fatigue	Face and neck	Combined CO_2 protocols	General dermal recovery and improved tone

Table 2 presents clinically relevant indications and treatment zones for non-invasive carboxytherapy. The synthesized evidence confirms its broad applicability, excellent tolerability, and efficacy across skin types and ages, supporting its role as the foundation of individualized aesthetic correction protocols in dermatocosmetic practice.

Discussion

Contemporary problematic-skin care increasingly relies on modular protocols in which each intervention is selected according to the predominant clinical component—whether vascular, pigmentary, or textural. Within this framework, non-injection carboxytherapy has established itself as a physiologically rational and safe modality, capable of both complementing—and in certain cases replacing—more aggressive procedures.

A review of systematic studies and clinical reports highlights significant advantages of transdermal CO_2 delivery compared with invasive and device-based alternatives. For example, Kroumpouzos [4] demonstrated that CO_2-enriched masks achieve pigmentary correction in the lower eyelid region on par with plasmapheresis, while offering markedly superior tolerability. Participants reported minimal discomfort and zero post-procedural complications, making the method particularly appealing for sensitive-skin patients.

Summarizing data from Zelenkova's review [5], non-injection CO_2 applications consistently alleviate vascular congestion, stimulate capillary blood flow, and support regenerative processes. Although dermal remodeling via transdermal CO_2 does not match the level achieved by fractional CO_2 laser, it boasts a far more favorable safety profile, a lower likelihood of adverse reactions, and no downtime.

Indications encompass the periorbital area and chronically hypoxic regions. Kołodziejczak and Rotsztejn [2] showed that CO_2-plus-acid gel masks effectively reduce both vascular and pigmentary components of dark circles, diminishing puffiness and enhancing local drainage. These outcomes are corroborated by both clinical assessment and visual-instrumental metrics. In his systematic overview, Bagherani [6] underscores non-invasive carboxytherapy's efficacy in treating striae and early-stage cellulite; regular gel-based applications promote skin tightening and diminish lipodystrophic unevenness.

Although some sources (e.g., Peixoto [7] and Kumar [9]) discuss injectable carboxytherapy results, such approaches fall outside the scope of this analysis, which focuses exclusively on transdermal protocols.

The standardization of procedures remains a critical challenge. At present, protocols differ in exposure time, product composition, application technique, and treatment frequency, making it difficult to compare outcomes. Moreover, most studies report only short-term effects, while data on the durability of results without maintenance sessions (beyond six months) remain fragmentary [6].

The adoption of unified efficacy scales—incorporating both subjective and instrumental measures (corneometry, VAS, photometric verification)—would enhance the reliability of comparisons across methods. Table 3 presents a comparative overview of the therapeutic effectiveness of non-invasive carboxytherapy versus alternative aesthetic skin-correction techniques.

Table 3 – Comparison of the Effectiveness of Non-Invasive Carboxytherapy and Alternative Methods in the Treatment of Acne Scars and Striae (Compiled by the author based on sources: [2], [4], [5], [6], [7])

Method	Target Condition	Effectiveness	Side Effects
Carboxytherapy (non-invasive)	Striae, vascular dark circles, lipodystrophy	Moderate to high	Minimal (transient erythema, warmth)
PRP	Post-acne pigmentation, scars	Moderate	Erythema, bruising
Fractional CO_2 laser	Deep scars, wrinkles	High	Hyperpigmentation, prolonged redness
IPL	Vascular lesions, photodamage	Moderate	Temporary swelling, burning sensation

As shown in Table 3, non-injection carboxytherapy consistently delivers a high tolerability profile alongside moderate-to-high clinical efficacy, especially in sensitive and low-tolerance areas. Although its dermal remodeling effect is somewhat less pronounced than that of laser-based methods, it retains a crucial role within comprehensive treatment protocols for patients seeking a physiologically gentle yet effective therapy without prolonged downtime.

Future research should focus on: Validation of unified, skin-type- and area-specific protocols; Expansion of long-term outcome data; Integration of CO_2-based protocols into standard multifaceted correction regimens

Conclusion

This study has systematically organized and synthesized current scientific evidence on the use of non-injection carboxytherapy within comprehensive care programs for problematic skin. The literature review indicates consistent clinical efficacy of this modality across a range of aesthetic and dermatological concerns—post-inflammatory pigmentation, striae, vascular irregularities, localized lipodystrophy, and pronounced signs of skin hypoxia.

Compared with other non-invasive approaches (fractional laser, IPL, PRP), transdermal carboxytherapy offers a superior balance of efficacy and safety, particularly when administered in courses or combined with acid peels and supportive skincare. Its mechanism—local hypercapnia, vasodilation, and fibroblast metabolic stimulation—confers unique value in gentle yet enduring strategies for skin-structure restoration.

Our comparative analysis clarifies the specific niche for non-injection CO_2 therapy in aesthetic correction. The most pronounced and reproducible benefits appear in the lower-eyelid area (brightening and oedema reduction), in striae management, and in early cellulite protocols. In these contexts, improvements in microcirculation, lymphatic drainage, and collagen synthesis are most evident, with both instrumental measures and patient-reported outcomes reflecting high satisfaction.

Nevertheless, the review uncovered significant methodological limitations in existing protocols. The lack of standardized parameters—exposure times, treatment frequency, formulations—and the paucity of long-term follow-up impede the development of predictive outcome models. On average, achieved effects persist for 5–6 months, but data on extended maintenance regimens remain sparse.

Overall, non-injection carboxytherapy—grounded in physiological rationale and supported by clinical evidence—emerges as a promising component of multi-layered care for sensitive and problematic skin. Our theoretical conclusions underscore the need for empirical studies prioritizing protocol standardization, patient stratification by skin condition, and integration of objective assessment methods into future clinical trial designs.

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